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Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-98048>

Journal Article

Published Version

Originally published at:

Stiefel, M; Knechtle, B; Rüst, C A; Rosemann, T (2013). Analysis of performances at the ‘Ironman Hawaii triathlon’ and its qualifier events with respect to nationality. *Journal of Science and Cycling*, 2(2):27-34.

Analysis of performances at the 'Ironman Hawaii triathlon' and its qualifier events with respect to nationality

Michael Stiefel¹✉, Beat Knechtle^{1, 2}, Christoph Alexander Rüst¹ & Thomas Rosemann¹

Abstract

The Ironman World Championship in Hawaii is assumed to be the most challenging Ironman triathlon in the world. Athletes intending to compete in 'Ironman Hawaii' need to qualify. The aims of this study were (i) to compare the participation of athletes between 'Ironman Hawaii' and its qualifier races regarding their origin, and (ii) to compare the top ten performances of selected nations in 'Ironman Hawaii' with the top ten performances of the same nations in qualifier races within one year. All finishers in 2010 in both 'Ironman Hawaii' and in the qualifier races were analyzed regarding nationality, sex and performance of finishers. For women, a higher percentage (27.2%) finished in 'Ironman Hawaii' compared to the qualifiers (18.9%). For men, a higher percentage (81.1%) finished in the qualifiers compared to 'Ironman Hawaii' (72.8%). In both 'Ironman Hawaii' and in the qualifiers, most finishers originated from the USA, followed by athletes from Germany and Canada. When the split and overall race times of the top ten finishers of the fastest nations were compared between the qualifiers and 'Ironman Hawaii', split and overall race times were faster in both women and men in the qualifiers compared to 'Ironman Hawaii'. In the qualifiers, the fastest women originated from the USA (551 ± 14 min), followed by athletes from Germany (563 ± 12 min) and Switzerland (574 ± 22 min). In 'Ironman Hawaii' the fastest race times were achieved by American women (571 ± 10 min), followed by women originating from Australia (600 ± 32 min) and Germany (623 ± 25 min). For men, the fastest race times in the qualifiers were reached by athletes originating from Germany (496 ± 7 min), followed by athletes from Australia (503 ± 10 min) and Great Britain (512 ± 9 min). In 'Ironman Hawaii', American triathletes (522 ± 11 min) were the fastest followed by German (526 ± 19 min) and Australian (532 ± 26 min) finishers. These findings showed that (i) split and overall race times were slower in 'Ironman Hawaii' compared to its qualifiers and (ii) American triathletes dominated both participation and performance in both 'Ironman Hawaii' and its qualifiers.

Keywords: triathlon, ultra-endurance, swimming, cycling, running

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Received: 24 November 2012. Accepted: 16 October 2013.

Introduction

The Ironman triathlon involving successively 3.8km swimming, 180km cycling, and 42.195km running is considered as one of the most challenging endurance events in the world (Lepers, 2008; Lepers & Maffioletti, 2001). The Ironman was conceptualized in 1977 in Hawaii with the idea of combining the three toughest endurance races in Hawaii, the 2.4mile 'Waikiki Roughwater Swim', the 112miles of the 'Around-O'ahu Bike Race' and the 26.2mile 'Honolulu Marathon', into one event, the 'Ironman Hawaii' (<http://ironmanworldchampionship.com>). The very first Ironman was held in 1978 in Honolulu, Hawaii, and involved 12 men where the winner finished after 11 h 46 min. The first women competed in 1978 with a finishing time of 12 h 55 min. In 1981, the course moved to Kailua-Kona, Hawaii, where 'Ironman Hawaii' is still held now as world championship (<http://ironmanworldchampionship.com>).

'Ironman Hawaii' is the World Championship in Ironman triathlon. Each year, around 50,000 triathletes compete in 24 Ironman races and five half-Ironman triathlons throughout the world to qualify for 'Ironman Hawaii' (<http://ironmanworldchampionship.com>). Most of the competitors have the aim to earn one of the 1,900 start tickets for the Ironman World Championship held every October in Kona, Hawaii. To qualify for 'Ironman Hawaii', official qualifying events award Ironman World Championship start places for age group finishers. In each race and in each category, final start place allocation should be representative of the actual number of age group starters. For example, if 8% of the age group starters are women aged 40-44 years, then 8% of the start places are allocated to women in 40-44 years category. Fewer athletes gain entry into the Ironman World Championship by being selected in the Ironman Lottery Program or by winning a start place through the Ironman's charitable eBay Auction (www.ironman.com).

Even if such a remarkable number of triathletes compete each year in this age group based qualification system, it is not known whether this system is able to select the top athletes in a fair way. A recent study comparing age group finishers between qualifiers for 'Ironman Hawaii' and 'Ironman Hawaii' showed differences for both participation and performance for



athletes in different age groups between 'Ironman Hawaii' and the qualifier races (Stiefel et al. 2013). Overall, triathletes aged 25-49 years and men were generally underrepresented in 'Ironman Hawaii' compared with the qualifier races. These athletes may have had less chance to qualify for 'Ironman Hawaii' than women or younger (<25 years) and older (>50 years) athletes (Stiefel et al. 2013). Other important sport games, *e.g.* the Olympic Games, use a nation based qualification system, whereas the best athletes of selected nations can qualify for the games (www.olympic.org).

The long duration of the event and the difficult race conditions make the 'Ironman Hawaii' to one of the most challenging endurance events and even to one of the most demanding Ironman triathlons (Lepers, 2008). The Ironman triathletes have to swim 3.86 km in the Pacific where wetsuits are inhibited. The swim is followed by a cycling time trial covering 180km with a total altitude to climb of ~1,400m where drafting is prohibited. To finish 'Ironman Hawaii', the athletes have to run a marathon over 42.2km. Hawaii's tropical climate in October with temperatures around 30 °C, a humidity around 70% and crosswinds up to 70km/h (www.to-hawaii.com/climate.php) makes the 'Ironman Hawaii' even more challenging. The high temperatures and the wind may influence mainly the cycling and the running performances (Lepers, 2008; Sparks et al., 2005; Wegelin & Hoffman, 2011).

As a result, the course records for both women and men seemed to be slower in the 'Ironman Hawaii' than in other Ironman races regardless of the high density of top athletes in Hawaii. The current course record in 'Ironman Hawaii' was set in 2011 by Craig Alexander (Australia) with 8 h 3 min 56 s. Chrissie Wellington (Great Britain) set the women's course record in 2009 with 8 h 54 min 2 s. For the qualifier races, Marino Vanhoenacker (Belgium) set in July 2011 in 'Ironman Klagenfurt' with 7 h 45 min 58 s the fastest Ironman race time for men. For women, Chrissie Wellington (Great Britain) set in April 2011 in 'Ironman South Africa' with 8 h 33 min 56 s the fastest time (<http://ironman.com/results>).

Ironman race performances in the 'Ironman Hawaii' have been analyzed in 2008 (Lepers, 2008) and in a few of the qualifier races (Gulbin & Gaffney, 1999; Rüst et al., 2012; Stiefel et al., 2012). However, a potential difference in overall race time and in the three split times between the Ironman World Championship in 'Ironman Hawaii' and its qualifier races is not known. Especially no study investigated participation and performance trends regarding the nationality of the finishers in both the qualifiers and in 'Ironman Hawaii'. A recent study investigated the participation and performance trends for athletes competing in 'Ironman Switzerland' in the heart of Europe as a qualifier for 'Ironman Hawaii' (Jürgens et al. 2012). Athletes from Central Europe dominated participation and finishers from Switzerland and neighboring Germany were the fastest (Jürgens et al. 2012). For other triathlon distances such as ultra-triathlons

covering two or more times the Ironman distance, trends in participation and performance for finishers regarding their nationality have been investigated (Jeffery et al. 2012; Lenherr et al. 2012; Lepers et al. 2011; Rüst et al. 2013; Sigg et al. 2012). Most of the races were held in Europe and European athletes were the fastest (Jeffery et al. 2012; Lenherr et al. 2012; Lepers et al. 2011; Rüst et al. 2013; Sigg et al. 2012). Especially for the Double Iron ultra-triathlon which was first held in the USA, the fastest athletes originated from Central Europe (Sigg et al. 2012).

Athletes intending to start in 'Ironman Hawaii' need to qualify within the same year. Therefore, the aims of this study were (i) to compare the participation of athletes between the Ironman World Championship 'Ironman Hawaii' and its qualifier races regarding their origin within one year, and (ii) to compare the top ten performances of selected nations in the Ironman World Championship 'Ironman Hawaii' with the top ten performances of the same nations in qualifier races within one year. We expected (i) an equal distribution of female and male participants in the qualifier races and in 'Ironman Hawaii' and (ii) slower overall race times in the 'Ironman Hawaii' compared to the qualifier races due to slower cycling and running split times because of the uncomfortable weather conditions in Hawaii independent upon the nationality of the finishers.

Materials and methods

All finishers in 2010 in both the 'Ironman Hawaii' as the Ironman World Championship and in one of its qualifier races were analyzed regarding performance in nationality and sex. The data set from this study was obtained from the websites of the Ironman races (www.ironman.com). The study was approved by the Institutional Review Board of St. Gallen, Switzerland, with waiver of the requirement for informed consent given that the study involved the analysis of publicly available data.

Data for the 24 Ironman races but not the five half-Ironman triathlons were collected. The distance and race times in the half-Ironman races are not comparable to the full Ironman distance. Complete data with nationality and race times from the Ironman World Series 2010 were available for the 'Ironman Hawaii' and for all qualifier races held in 2010 with exception of 'Ironman Texas', 'Ironman Wales' and 'Ford Ironman Cozumel'. From these three races, the complete rankings were not publicly available online and the race directors were not able to provide us data needed for analyses. All available data from the other 21 qualifier races were pooled prior to analysis.

In total, data were available from 41,367 athletes. A total of 1,847 athletes, including 503 women and 1,344 men, finished 'Ironman Hawaii' 2010. In the Ironman World Series 2010, the qualifier races for the World Championship, a total of 39,520 athletes, including 7,480 women and 32,038 men, finished.

Data analysis

To find similarities and differences in performance related to the nationality of athletes between 'Ironman Hawaii' and its qualifier races, from all countries providing in both the World Championship and in the qualifier races at least ten athletes per sex, the top ten (*e.g.* ten fastest total race or split discipline times) men and women per split discipline and overall race time were determined for the 'Ironman Hawaii' and for the pooled qualifier races. For women, sufficient data were available for athletes originating from Australia, Canada, Great Britain, Germany, Japan, New Zealand, Switzerland and USA. These eight countries provided a total of 449 women (equal to 89.3% of all women) in the 'Ironman Hawaii' and 6,286 women (equal to 84.0% of all women) in the qualifier races. For men, sufficient data were available for athletes originating from Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Spain, France, Great Britain, Germany, Italy, Japan, Mexico, Netherlands, New Zealand, Switzerland and USA. These 18 countries provided a total of 1,262 men (*i.e.* equal to 93.9% of all men) in the 'Ironman Hawaii' and 27,543 men (*i.e.* equal to 86.0% of all men) in the qualifier races. Additionally, similarities and

differences were determined in sex differences as previously described. Sex difference in nations could only be calculated for nations with sufficient data for men and women.

Statistical Analysis

In order to increase the reliability of data analyses, each set of data was tested for normal distribution as well as for homogeneity of variances prior to statistical analyses. Normal distribution was tested using a D'Agostino and Pearson omnibus normality test and homogeneity of variances was tested using a Levene's

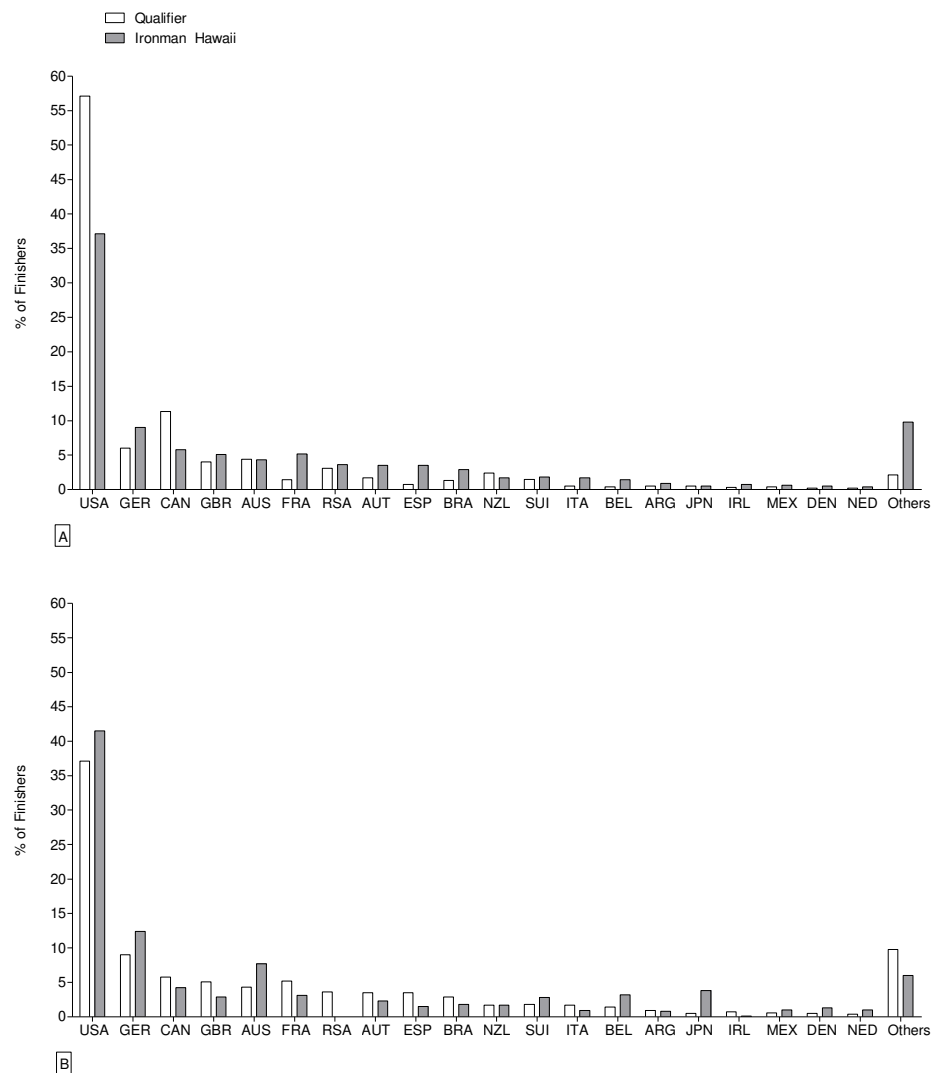


Figure 1. Percentage distributions of women (Panel A) and men (Panel B) finishers per nation in the qualifiers and in 'Ironman Hawaii'. Data are shown for the 20 nations with the overall highest number of participants

Table 1. Difference in performance for the top ten athletes for the fastest nations between qualifiers and 'Ironman Hawaii'.

Sex	Discipline	Qualifier	Ironman Hawaii	Difference	Significance
Women	Swimming	53.8±6.1 min	65.5±9.0 min	-11.3±7.2 min	P<0.0001
	Cycling	316.7±24.8 min	335.7±26.5 min	-19.0±4.4 min	P<0.0001
	Running	205.0±21.4 min	220.0±24.7 min	-15.0±6.5 min	P<0.0001
	Overall	594.3±54.6 min	638.6±62.1 min	-44.3±5.8 min	P<0.0001
Men	Swimming	48.1±2.9 min	57.2±4.4 min	-9.1±5.0 min	P<0.0001
	Cycling	277.5±8.9 min	290.8±11.3 min	-13.4±9.3 min	P<0.0001
	Running	177.6±11.4 min	186.4±14.6 min	-8.8±4.8 min	P<0.0001
	Overall	515.6±16.3 min	552.7±28.3 min	-37.1±11.4 min	P<0.0001

Table 2. Inhabitants in the countries with the highest numbers of finishers in both the qualifiers and in 'Ironman Hawaii'. Data from OECD Organization for Economic Cooperation and Development. www.oecd.org

Country	Population in 2011
USA	309,349,689
Germany	81,802,257
Canada	34,108,752
Great Britain	62,026,962
Australia	22,299,800
France	62,791,013
South Africa	49,991,300
Austria	8,375,290
Spain	45,989,016
Brazil	193,252,604
New Zealand	4,367,800
Switzerland	7,785,806
Italy	60,340,328
Belgium	10,839,905
Argentina	40,518,951
Japan	128,056,000
Ireland	4,467,854
Mexico	112,336,538
Denmark	5,534,738
Netherlands	16,574,989

test in case of two groups and with a Bartlett's test in case of more than two groups. Afterwards, specific tests for each questioning were applied as appropriate. To find significant differences between performance of multiple groups in 'Ironman Hawaii' and the qualifier races, a two-way analysis of variance (ANOVA) with subsequent Bonferroni post-hoc analysis was performed and to find significant differences between performance of multiple groups within qualifier races or within the World Championship, a one-way analysis of variance (ANOVA) with subsequent Tukey-Kramer post-hoc analysis was performed. Statistical analyses were performed with IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA) and GraphPad Prism (Version 5, GraphPad Software, La Jolla, CA, USA). Significance was accepted at $p < 0.05$ (two-sided for t -tests). Data in the text are given as mean \pm standard deviation (SD).

Results

Differences in participation between 'Ironman Hawaii' and the qualifier races

For women, a higher percentage (27.2%) finished in 'Ironman Hawaii' compared to the qualifiers (18.9%). For men, however, a higher percentage (81.1%) finished in the qualifiers compared to 'Ironman Hawaii' (72.8%). In both 'Ironman Hawaii' and in the qualifiers, most finishers originated from the USA, followed by athletes from Germany and Canada (Figure 1). In 'Ironman Hawaii', the percentage of female finishers was lower for American and Canadian and higher for German athletes. For men, the

percentage was higher for American and German, but lower for Canadian athletes.

Differences in performance between 'Ironman Hawaii' and the qualifier races

When the split and overall race times of the top ten finishers of the fastest nations (i.e. eight for women and ten for men) were compared between the qualifiers and 'Ironman Hawaii', split and overall races times were faster in the qualifiers compared to 'Ironman Hawaii' in both women and men (Table 1).

Figure 2 presents the overall race times of the ten fastest women (Panel A) and men (Panel B) in the qualifiers and in 'Ironman Hawaii'. In the qualifiers, the fastest women originated from the USA (551 ± 14 min), followed by athletes from Germany (563 ± 12 min) and Switzerland (574 ± 22 min). In 'Ironman

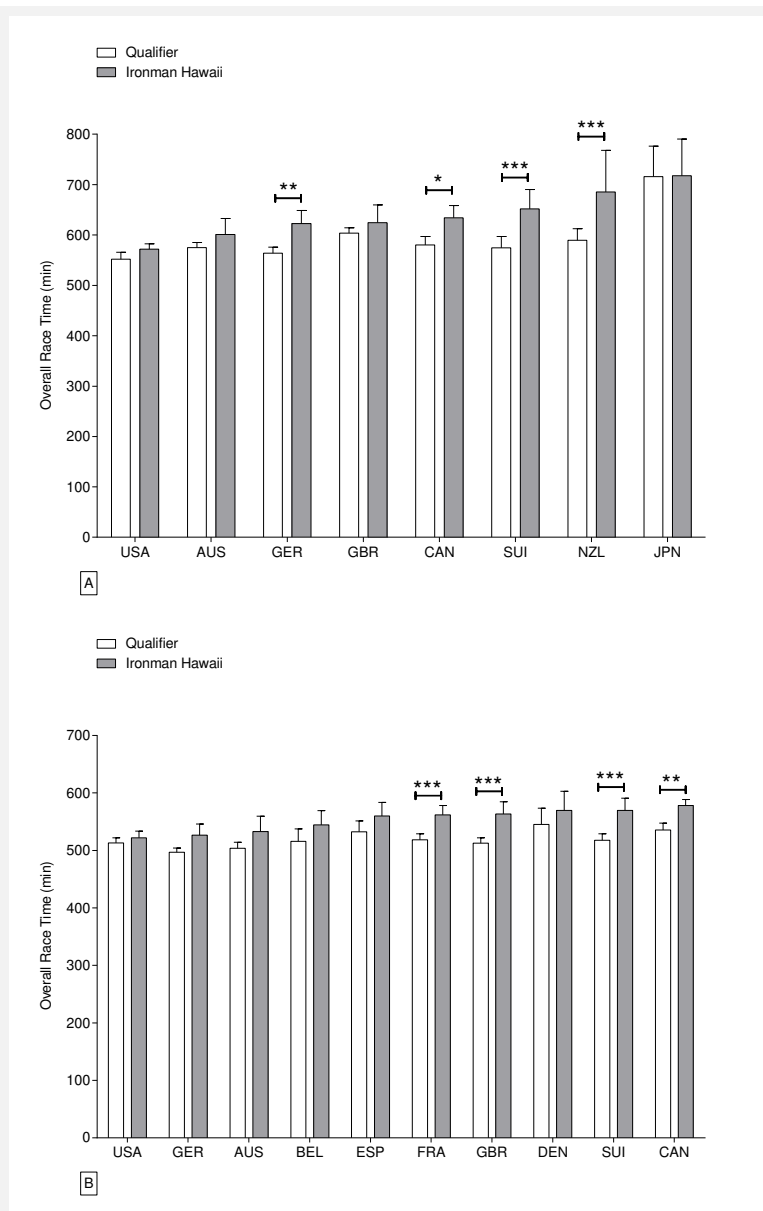


Figure 2. Race times of the athletes of the eight fastest countries for women (Panel A) and men (Panel B) in the qualifiers and in 'Ironman Hawaii'. (* = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$). USA=United States of America, AUS=Australia, GER=Germany, GBR=Great Britain, CAN=Canada, SUI=Switzerland NZL=New Zealand, JPN=Japan.

Table 3. Ironman qualifiers and qualifying slots for 'Ironman Hawaii' in 2012. Data from www.runtri.com

Country	Race	Qualifying Slots (2012)
USA	Ironman Arizona	65
	Ironman Coeur d'Alene	50
	Ironman Florida	65
	Ironman Lake Placid	50
	Ironman Louisville	50
	Ironman St. George	50
	Ironman Texas	50
	Ironman Wisconsin	50
	Ironman New York	75
	Ironman Germany	100
Germany	Ironman Regensburg	50
Canada	Ironman Canada	50
Great Britain	Ironman UK	50
	Ironman Wales	50
Australia	Ironman Australia	40
	Ironman Western Australia	40
	Ironman Melbourne	75
	Ironman Cairns	40
France	Ironman France	50
South Africa	Ironman South Africa	30
Austria	Ironman Austria	50
Spain	Ironman Lanzarote	40
Brazil	Ironman Brazil	50
New Zealand	Ironman New Zealand	40
Switzerland	Ironman Switzerland	50
Korea	Ironman Korea	50
Mexico	Ironman Cozumel	50
Sweden	Ironman Sweden	40
Total		1450

Hawaii' the fastest race times were achieved by American women (571 ± 10 min), followed by women originating from Australia (600 ± 32 min) and Germany (623 ± 25 min). Women from Germany, Canada, Switzerland and New Zealand were faster in the qualifiers than in 'Ironman Hawaii'. For men, the fastest race times in the qualifiers were obtained by athletes originating from Germany (496 ± 7 min), followed by athletes from Australia (503 ± 10 min) and Great Britain (512 ± 9 min). In 'Ironman Hawaii', American triathletes (522 ± 11 min) were the fastest followed by German (526 ± 19 min) and Australian (532 ± 26 min) finishers. Men from France, Great Britain, Switzerland and Canada were faster in the qualifiers compared to 'Ironman Hawaii'.

Figure 3 presents the split times in the qualifiers and in 'Ironman Hawaii' for women. For the swimming split, women originating from Australia, Canada, Great Britain, Germany, New Zealand, Switzerland and Japan were faster in the qualifiers than in 'Ironman Hawaii' (Panel A). American women, however, achieved the same split times in swimming in both the qualifiers and in 'Ironman Hawaii'. In cycling, women from Germany, Canada, Switzerland, and New Zealand were faster in the qualifiers than in 'Ironman Hawaii' (Panel B). For the marathon run, athletes from Germany, Switzerland and New Zealand were faster in the qualifiers than in 'Ironman Hawaii' (Panel C).

Figure 4 presents the split times in the qualifiers and in 'Ironman Hawaii' for men. For swimming, athletes from the USA, Germany, Australia, Belgium, Switzerland, France, Great Britain, Brazil, Canada and Denmark achieved all faster split times in the qualifiers than in 'Ironman Hawaii' (Panel A). For the cycling

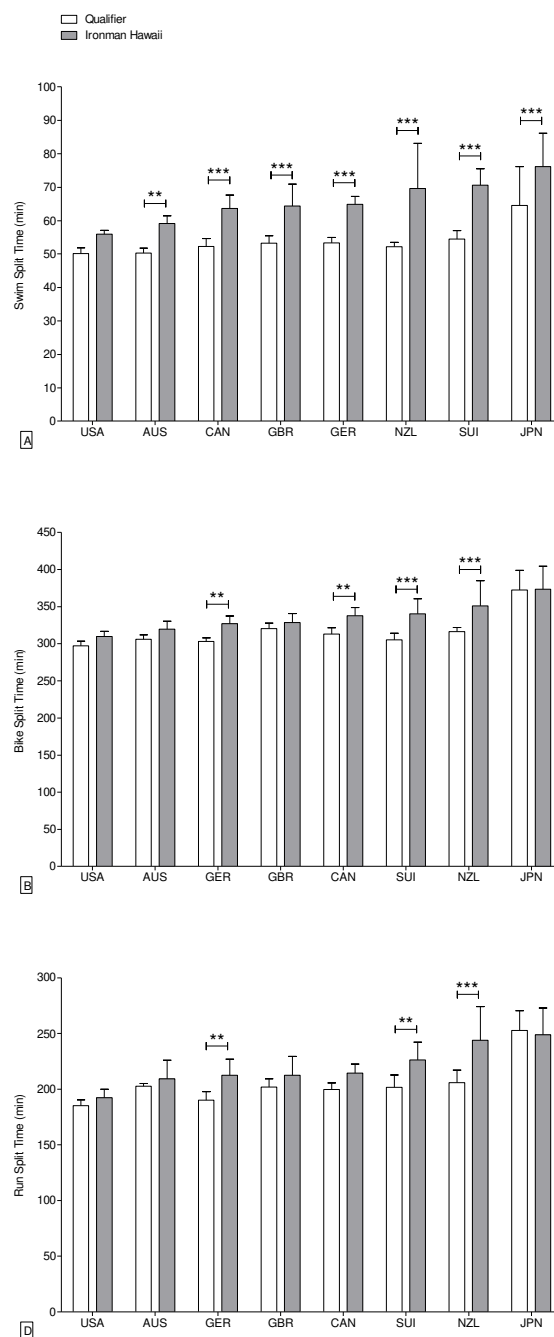


Figure 3. Performance for the top ten women per nation in the swim split (Panel A), cycling split (Panel B) and running split (Panel C) in the qualifiers and in 'Ironman Hawaii'. Asterisk above bars indicate significant differences in performance between qualifier race and 'Ironman Hawaii' (* = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$). USA=United States of America, AUS=Australia, GER=Germany, GBR=Great Britain, CAN=Canada, SUI=Switzerland, NZL=New Zealand, JPN=Japan.

split, athletes from Switzerland, Great Britain, France and Austria were faster in the qualifiers than in 'Ironman Hawaii' (Panel B). For running, Austrian and British athletes reached faster split times in the qualifiers than in 'Ironman Hawaii' (Panel C).

Discussion

This study intended (i) to compare the participation of athletes regarding nationality between the Ironman

World Championship and its qualifier races within one year, and (ii) to compare the top ten performances of selected nations in the Ironman World Championship with the top ten performances of the same nations in qualifier races within the same year. We expected slower overall race times in the 'Ironman Hawaii' due to slower cycling and running split times because of the uncomfortable weather conditions in Hawaii.

The most important findings were that (i) American women were the fastest in both the qualifiers and in 'Ironman Hawaii' whereas German men were the fastest in the qualifiers and American men the fastest in 'Ironman Hawaii', (ii) American and Australian athletes achieved in both women and men the same race times in both the qualifiers and 'Ironman Hawaii', (iii) women from Germany, Switzerland and New Zealand were faster in the qualifiers than in 'Ironman Hawaii' for overall race times and split times and (iv) swimming split times were slower in 'Ironman Hawaii' compared to the qualifiers with the exception for American women.

American dominance in participation and performance

In both the qualifiers and in 'Ironman Hawaii', most of the finishers originated from the USA, followed by athletes from Germany and Canada. Additionally, in 'Ironman Hawaii', both American women and men were the fastest. In the qualifiers, however, German men were the fastest.

A potential explanation for these findings might be the higher population of the USA compared to Germany. The USA has approximately 3.8 times more inhabitants compared to Germany and approximately 9.1 times more than Canada (Table 2). Additionally, US-American triathletes have more possibilities to qualify for the 'Ironman Hawaii'. In the USA, Ironman triathletes have the option to start in nine qualifiers with a total of 505 qualifying slots (Table 3). In Germany, however, there are only two qualifiers offering 150 slots. Nonetheless, German triathletes may go abroad, e.g. to Switzerland, to qualify for 'Ironman Hawaii' (Jürgens et al., 2012).

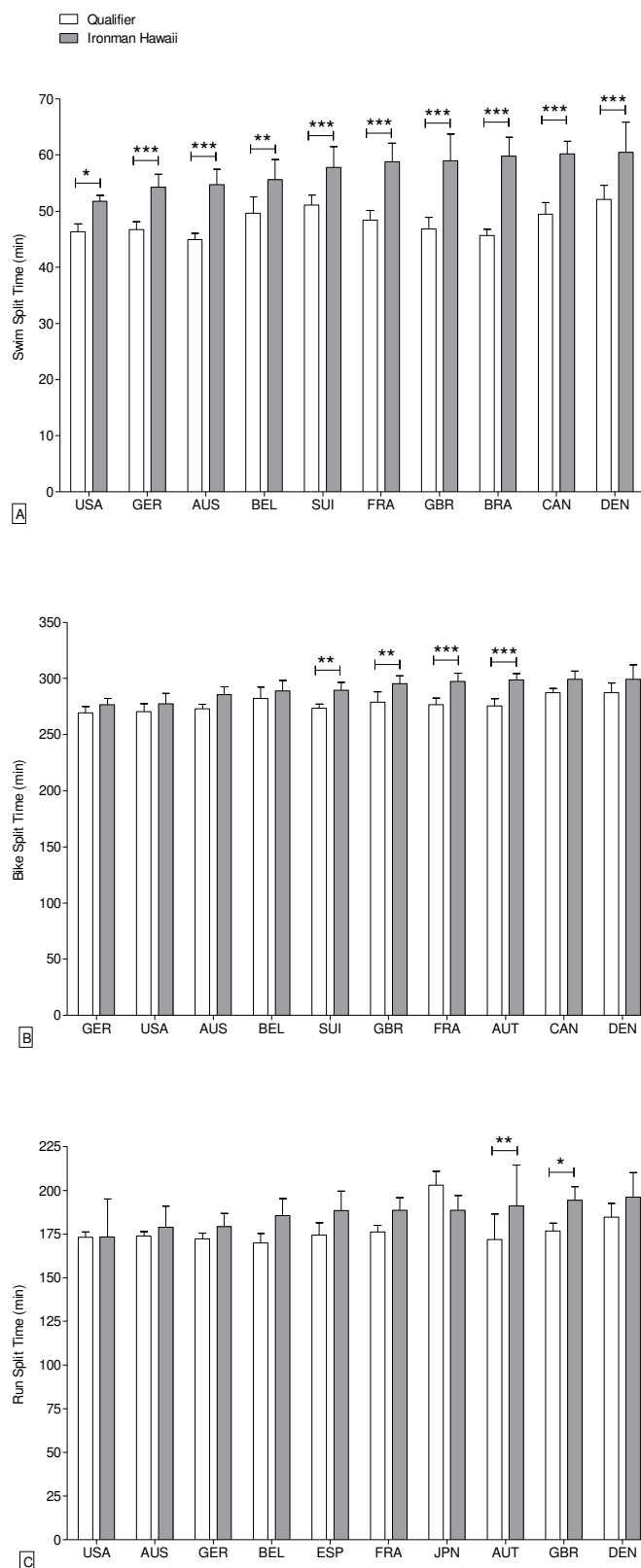


Figure 4. Performance for the top ten men per nation in the swim split (Panel A), cycling split (Panel B) and running split (Panel C) in the qualifiers and 'Ironman Hawaii'. Asterisk above bars indicate significant differences in performance between qualifier race and 'Ironman Hawaii' (*= p < 0.05; ** = p < 0.01; *** = p < 0.001). USA=United States of America, GER=Germany, AUS=Australia, BEL=Belgium, ESP=Spain, FRA=France, GBR=Great Britain, DEN=Denmark, SUI=Switzerland, CAN=Canada

Americans and Australians achieved the same performance in qualifiers and 'Ironman Hawaii'

An important finding was that the top ten American and Australian athletes achieved in both women and men the same race times in both the qualifiers and in 'Ironman Hawaii'. Hawaii is known to have a tropical climate with warm temperatures during the whole year (www.hawaiiweathertoday.com). Most probably both American and Australian athletes competing in both a qualifier and in 'Ironman Hawaii' are used to hot temperatures since also Australia has regions with very high temperatures (www.weatherzone.com.au). Ironman qualifier races in certain countries may be more identical to the 'Ironman Hawaii' regarding the climate than others, or the climate in certain countries may be more identical to the one in Hawaii. Athletes originating from European countries with rather cold climate such as Belgium, France, Great Britain, Denmark and Switzerland may prepare to compete in 'Ironman Hawaii' in a training camp in a region with a climate similar to Hawaii.

Faster race times in qualifiers than in 'Ironman Hawaii'

An interesting finding was that women from Germany, Switzerland and New Zealand reached faster overall and split times in the qualifiers than in 'Ironman Hawaii'. We assume that athletes from Germany, Switzerland and New Zealand qualified in their 'home races' such as 'Ironman Germany', 'Ironman Switzerland' and 'Ironman New Zealand'. A recent study showed that 31.9% of the participants in 'Ironman Switzerland' originated from Switzerland (Jürgens et al., 2012). A potential explanation for the faster split and overall race times might be the more favourable environmental conditions in the qualifiers held in Germany, Switzerland and New Zealand.

Slower swimming split times in 'Ironman Hawaii'

An important finding was that the swimming split times were slower in 'Ironman Hawaii' compared to the qualifiers with the exception for American women. Contrary to the assumptions, it is not the running or cycling course with the heat, the wind and the high humidity making 'Ironman Hawaii' to a slower race compared to its qualifiers, but it's the swimming course with its prohibition of wearing wetsuits. The swimming part seemed to be responsible for the slower race times in the 'Ironman Hawaii', since the ten fastest swimming split times for both sexes and all age groups and all nation groups except the American women's were slower in 'Ironman Hawaii' than in the qualifier races.

There are two main differences between the swimming part in 'Ironman Hawaii' and that one in some qualifiers. First, the use of wetsuits is prohibited in 'Ironman Hawaii'. Wetsuits increase the swim performance by increasing buoyancy (Cordain & Kopriva, 1991). Second, the swimming in 'Ironman Hawaii' is held in the Pacific, i.e. in salt water. This fact might also explain why only female American

triathletes were able to perform at the same level in 'Ironman Hawaii'. Female Ironman triathletes have more body fat (Knechtle et al., 2010) and they may profit more from the denser salt water (Lepers 2008; Toussaint et al., 1988).

American swimmers are known to be among the fastest in the world (Pyne et al., 2004). The background of a triathlete might be swimming, cycling and/or running. In case an elite American Ironman triathlete has a background as an elite swimmer, this might explain that American women achieve the same swim split times in the qualifiers and in 'Ironman Hawaii'.

Differences in the number of finishers between qualifiers and 'Ironman Hawaii'

It seems that the qualification system provides in percentage more start places to groups with fewer participants. This could be because at least one start place is allocated to each age group (<http://ironmanworldchampionship.com/qualification>). The Lottery Program and the eBay Auction may have other balancing effects on the distribution. The differences in the distribution of the nations between the qualifiers and 'Ironman Hawaii' might be due to the quality of the athletes, e.g. nations with more top athletes earn more start places, and secondly due to the locations of the qualifier races. Recreational athletes may prefer local events. Triathletes from certain nations may not seize their opportunity to start in 'Ironman Hawaii', because of financial, time or other reasons. As Ironman triathlon is an American invention, triathletes from USA still dominate the Ironman finisher field. American women were representing more than the half of the women's finishers in the Ironman World Championship as well in the qualifier races, while American men were representing ~40% over all Ironman races. This is in contrast to findings in Double Iron ultra-triathlons whereas only ~20% of all finishers were from the USA, while ~80% were originated from Europe (Sigg et al., 2012). Another explanation for the difference could be the fact that we excluded the five half-Ironman triathlons where athletes could qualify for 'Ironman Hawaii'.

Limitations

We are aware of some limitations of this cross-sectional data analysis. There was no information about the individual factors, like physiological (e.g., aerobic capacity) and anthropometric (e.g., body weight, lean body mass) characteristics (Knechtle et al., 2011a; Knechtle et al., 2011b), training (Gulbin & Gaffney, 1999; Knechtle et al., 2010), and race experience (Knechtle et al., 2010). A single triathlete could have been responsible for more than one analyzed result by achieving a top ten result in both a qualifier and in 'Ironman Hawaii'. The exact courses in the qualifier races were not known. The influence of weather conditions such as temperature, wind direction and velocity, rain and water temperature was unknown (Ely et al., 2007; Sparks et al., 2005; Vihma, 2010; Wegelin

and Hoffman, 2011). Only Ironman triathlon performances within one year were analyzed. Despite these limitations, the large number of more than 40,000 triathletes considered in the present study may give new insight into Ironman triathlon performances.

Conclusions

More women finished in 'Ironman Hawaii' compared to the qualifiers whereas more men finished in the qualifiers compared to 'Ironman Hawaii'. In both 'Ironman Hawaii' and in the qualifiers, most finishers originated from the USA, followed by athletes from Germany and Canada. The fastest women originated from the USA in both the qualifiers and in 'Ironman Hawaii'. In men, German athletes were the fastest in the qualifiers, but American athletes were the fastest in 'Ironman Hawaii'. Split and overall race times were slower in 'Ironman Hawaii' compared to its qualifiers. American triathletes dominated both participation and performance in both the qualifiers and 'Ironman Hawaii' with the exception for German men in the qualifiers. Future studies may determine the regions where American athletes originate. The investigation of the strategy of athletes originating from countries in Northern Europe such as Germany and preparing for 'Ironman Hawaii' may explain why these athletes are able to finish in the top ten in 'Ironman Hawaii'.

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